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Preliminary Assessment of Heavy Metals in Municipal Solid Waste Open Dump Sites around Madurai District

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ABSTRACT

The heavy metal pollution and distribution on solid waste and leachate have detected with the samples which were collected from the unregulated dumping site. Three dumping sites were selected Thirumangalam (DS1), Usilampatti (DS2) and Melur (DS3) around Madurai city. Eight metals were detected Mercury, Arsenic, Cadmium, Nickel, Lead, Copper, Chromium and Zinc. This paper discusses that the heavy metals concentration were high in solid waste than leachate in all dump site. The metals of Mercury, Arsenic and Cadmium were high in solid waste at Melur dumping site but Nickel, Lead, Chromium and Cadmium were high in Thirumangalam dumping site and Zinc only high in Usilampatti dumping site. Further in leachate sample the metals of Mercury, Cadmium, Lead, Copper and Zinc were high in Thirumangalam dumping site and Nickel ,Chromium were high in Melur dumping site but the Arsenic only high in Usilampatti.

Keywords: Municipal Solid Waste, Heavy metals, Leachate, Compost

Abbreviations: DS1-Dumping site 1,2,3, MSWM-Municipal solid waste management

1. INTRODUCTION

Municipal solid waste management (MSWM) is one of the major problems in India. Rapid industrialisation and urbanization increasing the level of heavy metals in municipal solid waste (MSW); (Esakku *et al.,* 2003). Solid wastes are generated by households and commercial establishments and collected by local Municipal Corporation and dump it in the yard. The discharge of heavy metals increased day by day on the dumpsite is nowadays a serious problem in urban and rural areas. This source of heavy metals has to do with human activities such as production of dental amalgam, paints, thermometer, soldering materials, batteries, cable coverings, ammunitions, pencils, plastics, X-ray shielding, crystal glass production and thinners (Brown, 1998;UsmanIdrisNda-Umar.,2012). Heavy metals could be referred to metallic chemical element that has a relatively high density and is toxic or poisonous at low concentration (Zaini Sakawi *et al.,* 2013). Heavy metals become toxic in human when they are not metabolized by the body and accumulate in the soft tissues. Heavy metals may enter the human body through food, water, air, cosmetics or absorption through the skin when they come in contact with humans (UsmanIdrisNda-Umar., 2012). They cannot be degraded or destroyed they may end up in solid waste during all life cycle. The main part of the heavy metals will be present when the discarded products are disposed off. Exposure of heavy metals may cause blood and bone disorders, kidney damage and decreased mental capacity and neurological damage and are carcinogenic, mutagenic even at very low concentration (Esakku *et al.,* 2003). In this study, heavy metal pollution and distribution a solid waste and leachate have detected with the samples which were collected from the unregulated dumpsite are in Madurai districts. Three dump sites were selected and compared the heavy metal contents.

2. MATERIALS AND METHODS

Site description

Madurai is one of the metropolitan city. In Madurai district four dumping sites are present. Only one site is actively involved in Solid waste management practice at Avaniapuram, Vellakkal site. But the other three dumping sites are not involved in such activities they are only dumping their waste in unregulated manner so that selected these sites for this study such as Thirumangalam (DS1), Usilampatti (DS2) and Melur (DS3). The latitude and longitude of these town is 9°91′N and 77°98′E,9.97°N 77.8°E. 10°03′N78°20′E10.05°N78.33°E10°03′N78°20′E10.05°N78.33°E respectively. They were collected their waste in and around their area dump it in the yard.

Methodology

Solid waste and Leachate samples were collected on May, 2013.

Solid waste sample collection

Sampling points were selected as the corners of equilateral triangle of 30m. Boreholes were drilled with 15cm manual auger and taken samples. The same procedure followed in other two dumpsites (Esakku, *et al.,* 2003). Triplicate samples were collected in each site. Samples were properly labelled and named as DS1, DS2and DS3 and brought to the laboratory for analysis.

Leachate sample collection

Perforated PVC pipes of 10 cm diameter were inserted in to the boreholes from which the solid samples were collected. And the top ends of the pipes with locking facility for leachate collection. Three leachate samples were collected randomly in each dumping site. This leachate were filtered and preserved for soluble heavy metal analysis.

Acid digestion for heavy metals analysis

Solid waste

After transportation, in the laboratory the bulk solid samples were spread on trays and were air dried at ambient conditions for two weeks. The samples were then grounded by mortar and pestle, sieved through a 2 mm mesh, and oven-dried at 50°C for about 48 hours and were stored at room temperature before analysis.

Samples (1.00 ± 0.001g each) were placed into 100 ml beakers separately, to which 15 ml of tri-acid mixture (70% high purity HNO_3, 65% $HClO_4$ and 70% H_2SO_4 in 5:1:1 ratio) was added. The mixture was then digested at 80°C till the solution became transparent (Allen *et al.,* 1986).

Leachate

The samples were digested with a drop of concentrated nitric acid. Samples were collected by 100 ml capacity with screw caps bottles. Bottles were pre-washed with nitric acid, rinsed with de-ionized water, dried and tested for contamination by leaching with 5% nitric acid.

Water sample (50 ml) was digested with 10 ml of concentrated HNO_3 at 80°C until the solution became transparent (APHA, 2005). The solution was filtered through Whatman No. 42 filter paper and the total volume was maintained to 50 ml with distilled water (Allen *et al.,* 1986).

Concentrations of Mercury (Hg), Arsenic (As), cadmium (Cd), chromium (Cr), Nickel (Ni) lead (Pb), copper (Cu) and zinc (Zn) in the filtrate of digested water samples were estimated by using an atomic absorption spectrophotometer.

Heavy metal analysis

Samples digested with acids, the resulting transparent solution was filtered and diluted to 50 ml using deionised water (Allen *et al.,* 1986).Then it was analysed for concentrations of Mercury (Hg), Arsenic (As), Cadmium (Cd), Nickel(Ni), Chromium (Cr), lead (Pb), Copper (Cu) and Zinc (Zn) using an atomic absorption spectrophotometer (Modal-ELICO,SL173).

Table 1 Heavy Metals content in MSW fine fraction

S.N	MSW Dump site	Hg	As	Cd	Ni	Pb	Cu	Cr	Zn
1	DS1	3.25	35.6	21.5	85.3	295.25	310.12	206.00	303.20
2	DS2	2.55	32.13	19.9	53.0	290.15	298.40	98.61	380.11
3	DS3	4.28	41.20	22.3	61.2	300.31	304.30	170.20	310.0
4	Indian compost standard *	0.15	10.0	5.0	50	100	300	50	1000
5	USPEA Compost standard **	17.0	41.0	39.0	420	300	1500	1200	2800

All the values are in mg/kg, triplicate samples were taken, on May 2013.
*MSW (Management and Handling) rules, 2000.
** US composting council, 1997

Figure 1 Heavy metals content in MSW fine fraction

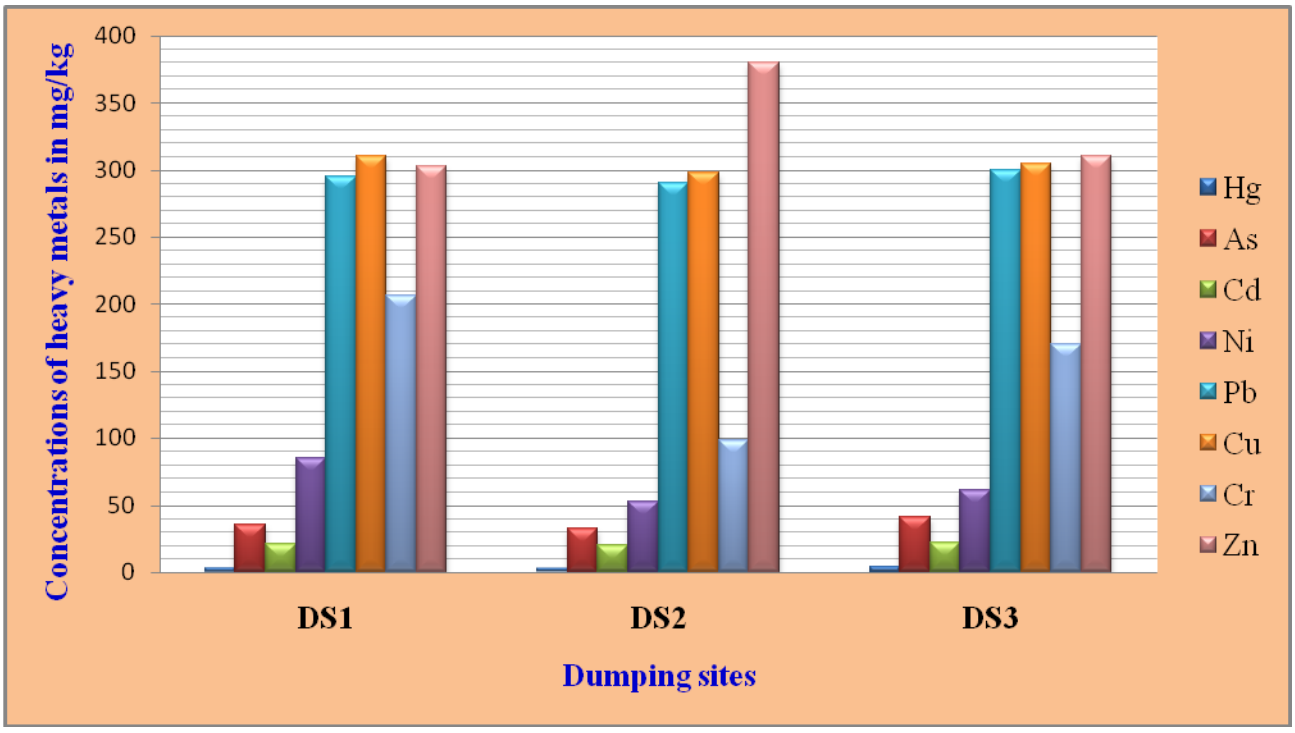
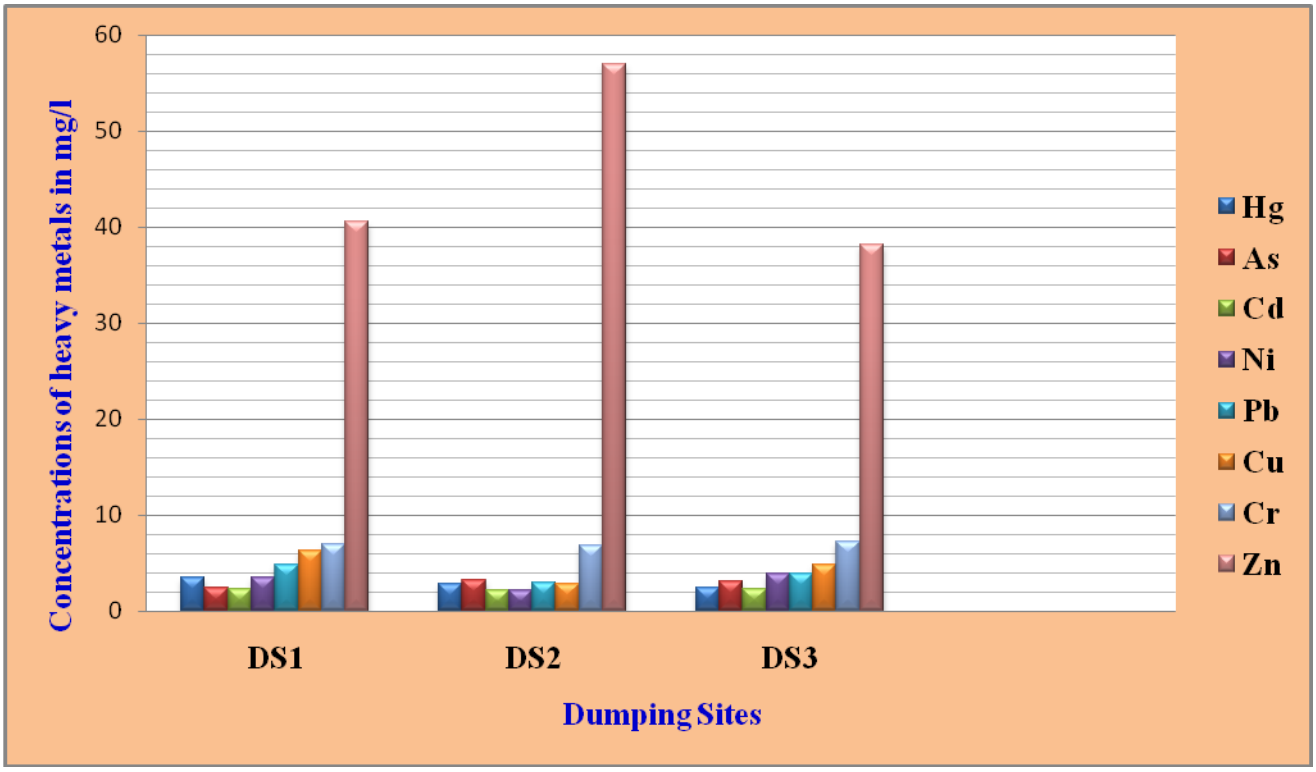


Table 2 Heavy metals content in MSW leachate

S.N	MSW Dump site	Hg	As	Cd	Ni	Pb	Cu	Cr	Zn
1	DS1	3.5	2.38	2.35	3.50	4.85	6.29	6.92	40.61
2	DS2	2.85	3.25	2.23	2.15	2.99	2.9	6.88	57.0
3	DS3	2.5	3.13	1.75	3.92	3.96	4.85	7.25	38.2

Figure 2 Heavy metals content in MSW leachate



3. RESULTS

Solid wastes

The statistical analysis of the results of heavy metal contents of the MSW fine fractions collected from different dumpsites around Madurai district are presented in table1. Nearly eight metals were analysed from which the levels of Zn (303.20,380.11,310.0mg/kg) were high in DS1,DS2 and DS3 respectively. Cr was high in DS1(206 mg/kg)than DS3(170.20mg)and DS2(98.61mg).Cu was almost same in three sites DS1(310 .12mg) DS2(304.3mg) DS3(298.40mg). Pb level also same like Cu and the concentration of Pb in DS3 was (300.31mg), DS1 (295.25mg) and DS2 (290.15 mg). Ni concentration were slightly increased in DS1 (85.3mg) thanDS3 (61.2 mg) and DS2 (53mg). Cd were nearly the same in all sites (21.5, 19.9 and22.3mg/kg).As level were high in DS3 (41.20mg) than DS1 and DS2 (35.6, 32.13mg) respectively. Finally the level of mercury was high in DS3 (4.28mg), DS1(3.25mg) and DS2(2.25mg). Study conducted by several researchers and it was revealed that high levels of heavy metals particularly Pb, Cd, Cu and Cr in soil near MSW dumping sites (Kimani, 2010; Awokunmi *et al.,* 2010; Adelekanand Alawode, 2011). The comparison of metal content with Indian standards for compost shows that the concentration of all metals except Cu and Zn exceed the limits. But when compared with USEPA standard all metals were within the limits.

Leachates

The Leachates samples were collected from the same location of solid waste and heavy metals were analysed and represented in table 2. The Zn levels were very high in all sites than other metals. The concentration of Cu and Cr were same in DS1 (6.29, 6.92 mg/l). Cr level was almost same in all sites (6.92, 6.88 and 7.25mg/l). Cu level were low in DS2 (2.9mg) than DS1 and DS3 (6.29, 4.85mg/l). Pb level were high in DS1 (4.85mg) and decreased in DS3 and DS2 (3.96, 2.9mg/l). Ni concentration were high in DS3 3.92mg/l than DS1 and DS2 (3.50, 2.15mg/l). As and Cd were same in DS1 (2.38, 2.35mg/l), the Cd level decreased in DS2 and DS3 (2.23, 1.75mg/l) but the as level were increased in DS3 and DS2 (3.13, 3.25mg/l) respectively. Finally the Hg concentration High in DS1 3.50mg and decreased slightly in DS2 and DS3 (2.85, 2.5mg/l). The comparison of metal content with WHO permissible limits in irrigation water shows that the concentration of all metals exceed the limits.

4. DISCUSSION

The concentration of the selected heavy metals in MSW collected from three dumping site around Madurai and were analysed. The concentrations of heavy metals were high in solid waste than leachate. From the results of three sites solid waste the metals of Hb, As, Cd and Pb were high in DS3. At the same time Ni, Pb, Cu and Cr were high in DS1in solid waste. The Zn was high in DS2 389mg/kg than DS1 and DS3. But the levels of all the metals in DS2 were low except Zn). The concentrations of all metals in solid waste exceed the limits when compared with Indian standard for compost, but which are within the limits when compared with USEPA standard. In leachate sample the concentration of Hg, Cd, Pb, Cu and Zn were high in DS1 than other site. The level of Ni & Cr were increased in DS3 than DS1 and DS2.When compare to solid waste the leachate samples heavy metals concentration were low. But the comparison of metal content with WHO permissible limits in irrigation water shows that the concentration of all metals exceed the limits in leachate (Chiroma *et al.,* 2014). Because industries and factories are present around the sites of DS1 and DS3.So the concentrations of heavy metals were high in both sites. Barjinder Bhalla *et al.,*2013 reported that Seasonal variations particularly during rainy season values of various parameters increased, reason being with time the solid waste material degraded and the waste constituents percolated down along with rainwater. Thus the age and seasonal variations has a significant effect on leachate composition. Many studies have shown that MSW leachate receive loads of contaminants that are usually greater than in the surrounding sub urban or rural areas due to the concentration of anthropogenic activities of urban settlements (Charlesworth *et al.,* 2003; kormanicki, 2005; Othman and ghandour, 2005; Lee *et al.,* 2006;Yang *et al.,* 2006; Srivastava and Jain, 2007; Awasthi, 2013). Also the people living and schooling near the dump sites indicated a high incidence of diseases that are associated with high exposure levels to these metal pollutants (Amusan *et al.,* 2005).

5. CONCLUSION

The results of the study clearly indicate that the level of Hb, AS, Cd and Pb were high in Thirumangalam dumping site than Usilampatti and Melur. Some metals of Ni, Pb, Cu and Cr were high in melur dumping site than other two sites. This indicates that the Thirumangalam and Melur sites are industrially active sites than Usilampatti. And also in these three sites municipal solid waste are dumping in an unregulated manner. All the metals in solid waste are exceed the limits when compared to Indian standard of compost but within the limits in USEPA standard. Like solid waste all the metals in leachate exceed the limits when compared with WHO permissible limits of irrigation water. This indicates the levels of metals must be reduced. Conventional techniques to remove heavy metals, e.g., precipitation, ion exchange, reverse osmosis, electrolysis, ultra filtration, composting, and phyto-remediation are commonly used in industries. However most of these technologies are becoming uneconomical and unfavourable to remove heavy metals from land filling site. But the composting process especially windrow composting is best method for waste reduction as well as heavy metal bioremediation economically and eco-friendly.

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